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Plasma generation and diagnostics for plasma-based laser pulse compression

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The peak power of lasers has increased dramatically since the invention of the chirped-pulse amplification (CPA) technique in 1985 [1]. Nowadays several PW (petawatt) lasers are available around the world and they are used for diverse scientific research. In the CPA lasers, the frequency-chirped laser pulse is amplified in several amplifiers and then it is compressed by gratings in vacuum, leading to a high peak power. In this scheme, however, the gratings have a certain damage threshold, so they should be large enough. In current PW lasers, the grating sizes are ~1 m already and it is very difficult to make larger gratings. In order to overcome the limitation of the grating-based CPA lasers, we proposed a new idea for laser pulse compression recently, which is based on a damage-free plasma with a density gradient [2]. In this new idea, a negatively (unlike conventional CPA lasers) frequency-chirped laser pulse is amplified in several amplifiers and then it is sent into a plasma with a certain density profile. The plasma is a dispersive medium for the laser pulse, so the frequency components in the laser pulse are reflected at different locations in the plasma, resulting in pulse compression after reflection from the plasma. The laser pulse compression idea using a density-gradient plasma was confirmed by extensive 2D and 3D PIC (particle-in-cell) simulations already [2].

Now we are trying to demonstrate the idea by experiments. In order to do it, a high density plasma should be generated for reflection. For this purpose, a laser pulse is sent onto a surface of a solid target like an aluminum or CH target. Extensive hydrodynamics simulations have been performed to develop a suitable high density plasma target. At the same time, a high density aluminum plasma was generated by a Ti:sapphire laser pulse, and its plasma density and density profile were measured by a laser interferometer employing a frequency-tripled laser pulse of the Ti:sapphire laser, as shown in Figure 1. In this talk, the on-going progress in the laser pulse compress experiment, especially the recent plasma generation and diagnostics result, will be reported.

References

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